

MARCH 1997

## BUILDING SEALING AND VENTILATION

**E**nergy-efficient houses not only conserve energy and money, but provide their owners other benefits as well. Chief among these is a cleaner environment. Less energy used means less fossil fuels burned – whether by gas combustion appliances or by the power generation plant – resulting in reduced emissions of pollutants such as carbon dioxide (CO<sub>2</sub>), the major greenhouse gas.

Greenhouse gases collect in the earth's atmosphere and act as an extra insulation layer, increasing the earth's surface temperature, a harmful effect known as global warming.

Stricter state energy codes, improvements in construction techniques, better components and consumer awareness have contributed to new levels of air tightness or "envelope" tightness in new and remodeled houses. Depending on the appliances, components and sealing method, tighter houses can be 15% to 30% more energy efficient than their 10 year old counterparts, often saving \$400 or more in annual energy costs.

There are a number of government, utility and industry

programs working to help contractors build more energy efficient houses. These programs are often limited in their ability to recommend specific products. This guide provides that type of detailed information and recommends specific products available for installation in energy efficient homes.

In this report, Green Seal recommends:

- 1) specific sealants to reduce infiltration of outside air; and
- 2) energy efficient fans for active ventilation designs.

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## Air Tight Envelope

Sealing a house's envelope reduces outside air infiltration and associated heating and cooling losses. Controlling infiltration improves comfort by reducing drafts and also reduces the intrusion of outside noise. Tightening a home requires that construction joints, cracks and penetrations in walls, floors and ceilings be sealed to reduce "accidental" ventilation.

While an air-tight house is desirable from an energy efficiency standpoint, it may not always be a comfortable or healthy house. A house can have a high energy rating, yet suffer from poor HVAC

distribution, poor air quality and uncontrolled humidity levels. Because many household and construction products release noxious gases over time, tight houses require some form of active ventilation to keep the indoor air from becoming stale or even hazardous. Mechanical ventilation systems can introduce outdoor air in a controlled manner and improve indoor air quality (IAQ) and occupant health, reduce odors, improve comfort and help a home comply with recommended ventilation standards.

In this report, we recommend products that can help houses become more air-tight, as well as products that aid in house ventilation. We rate a number of general-purpose caulks from major manufacturers based on their volatile organic compound (VOC) levels, ingredients, ease of cleanup and estimated lifetime. We also discuss active ventilation design and rank available products based on fan performance, noise levels, and manufacturer warranties.

## Caulks

It pays to focus on simple measures that guard new homes from infiltration — caulking, weatherstripping and insulation. Assuming that the rest of the components fit well, caulking

(sealing around wall penetrations, window and door openings, joints and other air gaps) is the most important measure to guard against drafty infiltration and to ensure a tight fit.

It is usually false economy to use the lowest priced products available — it will cost you both in money and reputation if you have to redo the job somewhere down the line. Acrylic latex, polyurethane and silicone based caulking and sealing products are more expensive than PVC and oil based ones, but they tend to last three to five times longer. Using long-lived products also helps the environment because it reduces the manufacturing, transportation, and disposal impacts of these products. Tightly sealed houses tend to last longer as well.

## Caulk criteria

We used the criteria below to evaluate and recommend caulking compounds.

■ **Longevity/durability.** A life span of more than five years. In general, longer lasting products make both economic and environmental sense.

■ **Ease of clean up.** Products that can be cleaned up with water or simple solvents. For certain applications, acrylic-based products are worth considering because they do not require harsh chemicals for clean up.

■ **Low VOC levels.** VOC levels of less than 80 g/l for latex/acrylic/silicone products, and 200 g/l for polyurethane based caulks. Lower VOC products emit less during curing and over their lifetime, thus reducing indoor and outdoor air pollution.

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## Types of Caulking Materials

**WHAT'S INSIDE THE TUBE?** Most caulks have a petrochemical base such as oil, resin, butyl rubber, vinyl acrylic, acrylic, polyethylene, polyurethane, polyvinyl acetate, etc. Additives such as stabilizers, preservatives and plasticizers give the caulks their final properties. The chart below lists the major types of caulking compounds and suggested applications.

BASE TYPE	RETAIL \$ (per 10 oz)	EST. LIFE (years)	USES	CLEAN UP
Oil	1.00 - 2.00	1 - 3	Most dry surfaces*	paint thinner
Polyvinyl acetate	1.50 - 2.00	1 - 3	Indoor surfaces only*	water
Styrene rubber	2.00 - 2.50	3 - 10	Most dry surfaces*	paint thinner
Butyl	2.50 - 3.00	4 - 10	Masonry and metal**	paint thinner
Acrylic latex	2.00 - 4.00	5 - 20+	Most dry surfaces*	water
Kraton	5.00 - 7.50	10 - 15	Most dry surfaces*	paint thinner
Polyurethane	4.50 - 10.00	15 - 20+	Masonry**	acetone, MEK
Silicone	4.00 - 7.00	20+	Glass, Aluminum* (not for masonry)	paint thinner, naphtha, toluene

\* wood, drywall, aluminum; e.g. gaps in wood frames around perimeter of house, plumbing penetrations, gaps in rough openings around windows and doors, boots around supply and return HVAC grills, seal between bottom plates and subfloor

\*\* gaps in masonry construction

The joint between a frame's seal plate and a masonry foundation has historically been sealed using caulk or adhesive, and can be a labor intensive process. A new alternative for sealing this and other long linear joints is foam tape. This product can be faster to apply and provides a good seal by expanding to fill gaps.

### ■ Non-hazardous materials.

Products that are not formulated with certain hazardous materials, primarily asbestos, formaldehyde, and heavy metals such as cadmium, chromium, lead and mercury. Avoiding these chemicals reduces the chances of their polluting the soil or groundwater.

## Ventilation

Most fresh air enters a house through and around windows, doors and other unsealed openings. This air is pulled in by negative pressures created by a variety of conditions, including point exhaust fans (bathroom, kitchen, etc.) Outside wind, air temperature differences and small

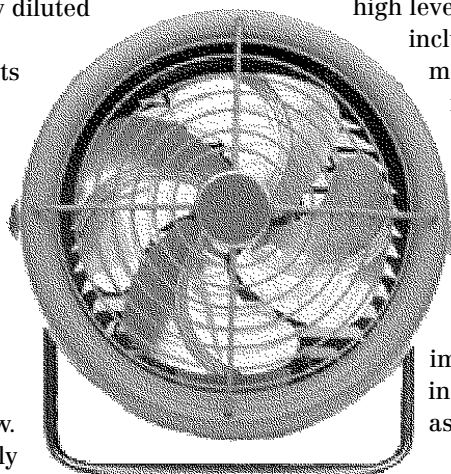
openings that are found throughout the house all contribute to a continuous exchange of inside and outside air. This uncontrolled ventilation stresses the heating and cooling systems, but has traditionally diluted indoor contaminants to nuisance levels.

An "air-tight" house is desirable from an energy-efficiency point of view. But an overly

tight house can contribute to a variety of problems, including poor indoor air quality, high (or low) humidity, and mold and mildew growth. Without adequate ventilation, indoor air can build up high levels of contaminants

including VOCs, carbon monoxide (CO) or even radon. Negative pressure inside a tight house can also cause backdrafting of flue gases from the furnace or other combustion appliances. While improving the air quality inside can be as simple as opening doors or

*Continued on page 4*



## Ventilation

*Continued from page 3*

windows, this may not be feasible in the wintertime or when summer humidity is reaching its peak.

To compound the issue, every home has individual factors which affect indoor air quality. These range from the number of occupants and their personal habits, to pets, furniture, carpeting and cleaning products. The effects of long term human exposure to a number of indoor air pollutants are yet unclear; human tolerance levels of certain chemicals also vary. Efforts to determine various "safe" levels of indoor air pollutants are being carried out by a number of organizations, including the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) and the EPA.

## How much outside air?

The quality of indoor air currently relies on another yardstick – air change per hour. An air change is defined as the volume of outside air needed to completely replace the volume of air inside a house. According to ASHRAE, the current guideline is 0.35 air changes per hour (ACH). This means there should be enough fresh air introduced to completely renew the air in the house roughly every three hours.

Municipalities that require energy-efficient construction have moved to make "active ventilation" part of the construction code. But even in municipalities where building codes do not require ventilation, builders who build tighter homes should consider active ventilation. Even though active ventilation consumes energy, the amount of energy required annually to ventilate a tight home is

still less than the additional amount of energy needed to heat or cool a leaky home.

## What is an active ventilation system?

An active or mechanical ventilation system is used to introduce a predetermined volume of fresh air into the home. Conventional homes usually just have bathroom exhaust fans and may have a hood over the stove. Standard bath fans do not really induce much outdoor air into a dwelling, as they are intended to operate for short periods of time to remove local odors and humidity. Typical fans are not designed for many years of energy-efficient continuous operation, or for low, unobtrusive noise levels.

An active ventilation system design can range from high-efficiency exhaust fans set to run periodically, to a stand-alone system where a dedicated exhaust fan works together with separate inlet(s) and outlet(s) to facilitate air exchanges; to using the house's forced-air heating and ventilation system to pull in fresh air from the outside.

The basic system generally consists of:

- an exhaust fan or another method to remove the stale air,
- a fresh air inlet (or inlets) to bring in outside air. For an integrated system, a duct brings outside air to the return side of the forced-air system's air handler.
- a balancing damper or other device that can limit the flow of fresh air into the system, or an electrically-operated damper to close the system when not needed, and

*Continued on page 7*



### A RULE OF THUMB

#### *How to approximate reasonable air exchange*

You need 15 cubic feet per minute (CFM) per person, or the recommended ACH, whichever is greater. In the case of houses, the number of persons can be approximated as the number of bedrooms plus one.

**FOR EXAMPLE:** For a four-bedroom, 2,000 square foot house with 8 foot ceiling and 4 bedrooms, the required air change can be calculated as follows (house volume = 2,000 x 8 = 16,000 cubic feet):

$$\text{minimum ACH} = 0.35 \times 16,000 / 60 = 93 \text{ CFM}$$

**OR**

$$\text{bedroom plus one} = 5 \times 15 = 75 \text{ CFM}$$

In this case, the house requires at least 93 CFM of air movement to provide adequate ventilation, since 75 CFM only provides 0.28 ACH.

## Recommended Products

The chart below contains products recommended by Green Seal, using the criteria discussed in the text. The products listed are from companies that responded to Green Seal's request for technical information. An explanation of the categories is provided below.

COMPANY	PRODUCT NAME	CAULK TYPE	VOC (g/l)	CLEAN	MSDS	ASTM TEST	TESTED BY	WARRANTY /EST. LIFE
DAP	Energy Saver Alex Plus	acrylic/silicone	25	H2O	√	C834	Int/Ext	50 yrs
		acrylic/silicone	40	H2O	√	C834	Int/Ext	35 yrs
Darworth (Polyseamseal)	Polyflex Acrylic Caulk	silicone	15-28	H2O	√	C920	Ext	50 yrs
		acrylic	14-42	H2O	√	C834	Ext	35 yrs
Gloucester (Phenoseal)	Vinyl Adhesive Caulk Surpass	vinyl	187	H2O	√*		Ext	NA
		acrylic	50-119	H2O	√*	C920**	Ext	NA
Hilti	CS-2130	polyurethane	82	Solvent	√	C920	Int	NA
Macco (Liquid Nails)	Super Caulk LC Painter's Caulk	acrylic/silicone	20-40	H2O	√	C920	Int	35 yrs
		acrylic	70	H2O	√	C834	Int	15 yrs
Macklanburg- Duncan	Silicone XL MD One 35 Year	silicone	NA	Solvent	√	C920	Int/Ext	50 yrs
		urethane/acrylic	NA	H2O	√		Int/Ext	NA
		acrylic/lat/silicone	NA	H2O	√	C920	Int/Ext	35 yrs
OSI	Acrylic Latex Siliconized A-L Pro-Stik	acrylic	41	H2O	√	C834	Int	NA
		silicone/acr/latex	41	H2O	√	C834	Int	NA
		vinyl	68	H2O	√	C920	Int	NA
Red Devil	Lifetime 25-Year Acrylic	silicone	34	H2O	√	C834	Int	life
		acrylic	34	H2O	√	C834	Int	25 yrs
Percora	AC-20+	acrylic/silicone	31	H2O	√	C834	Int/Ext	NA
Wal-Mart	House Beautiful	acrylic	41.6	Solvent	√	C920	Ext	15 yrs

\* According to their labels, these products are non-toxic

\*\* Meets the performance section of this standard only.

**VOC** The levels listed are values in grams per liter (g/l). Where more than one value appears for a particular product line, the higher level is generally for products with colorants. Generally, latex and silicone are lower in VOC content than polyurethane- or acrylic-based products. (Hilti's is the lowest VOC polyurethane that we found).

**Cleanup** Most products selected require only soap and water for cleanup; a number required simple solvent (mineral spirits) for cleanup.

**MSDS** The check mark (√) indicates that Green Seal has evaluated the product's MSDS and found no asbestos, formaldehyde or heavy metals listed (Federal regulations require the listing of hazardous or toxic ingredients greater than 1% by weight).

**ASTM Test** There are two general specifications that apply to caulks and sealants. The American Society for Testing and Materials' ASTM C834 describes caulk characteristics, such as extrusion, flexibility and adhesion. ASTM C920 (referenced by Federal Standard TT-S-00230C) includes more performance requirements, such as durability, "adhesion-in-peel" and weathering. Generally, silicone-based caulks are more likely to meet the performance required by ASTM C920. At a minimum, look for caulks that meet C834.

**Tested By** "Int" indicates internal/on-site laboratory tests; "Ext" indicates outside laboratory testing. We have found that testing of products, as well as products standards vary widely. Many manufacturers have on-site laboratories that perform these tests, some use outside laboratories, others use both. Green Seal was unable to verify each individual products' test results.

**Warranty/ Est. Life** Duration of limited product warranty, or estimate of product life provided by manufacturers (where available) to indicate the potential lifetime of products.

## Recommended Products

This chart contains products recommended by Green Seal, using the criteria discussed in the text. The products listed are from companies that responded to Green Seal's request for technical information. An explanation of the categories is provided in the column to the right of the chart.

COMPANY	MODEL	VOLUME (CFM)	NOISE (Sone)	POWER (W)	BEARINGS	HRS OR WARRANTY	PRICE (EST)	AVAIL.
<b>BATHROOMS/ROOM VENTILATING FANS (HVI RATED AT LESS THAN 100 CFM)</b>								
American Aldes	CMV80	80*	0.8	32	√	80 K/2 yrs	75-100	C/D
	CMV100	95*	1.2	34	√	80 K/2 yrs	75-100	C/D
Fan America	SMV80	80	0.8	35	√	1 yr	80	C/D
NuTone	QT80	80	1.5	55*	√	life	165	G
	QT90	90	1.5	55*	√	life	177	G
Panasonic	FV-05VQ	50	0.5	13.2	√	30 K/1 yr	105	C/D
	FV-07VQ	70	0.5	15.4	√	30 K/1 yr	110	C/D
	FV-08VQ	90	1.0	17.4	√	30 K/1 yr	120	C/D
<b>HOUSE/AREA VENTILATING FANS (HVI RATED FROM 100 TO 200 CFM)</b>								
Aldes	CMV125	120	1.5	40	√	80 K/2 yrs	75-100	C/D
	CMV200	195	3.5	70	√	80 K/2 yrs	75-100	C/D
Fan America	SMV100	100	1.2	37	√	1 yr	100	C/D
	SMV140	120	1.5	40	√	1 yr	110	C/D
	SMV200	200	3.5	77	√	1 yr	120	C/D
Fan Tech	FR150	125	NA	48	NA	3 yrs	120	C/D
NuTone	QT110	110	2.0	71.5*	√	life	170	G
	QT130	130	1.0	110*	√	life	185	G
	QT150	150	2.5	66*	√	life	190	G
	QT200	200	4.5	110*	√	life	210	G
Panasonic	FV-11VQ	110	1.5	20.4	√	30 K/1 yr	130	C/D
	FV-20VQ	195	1.5	39.5	√	30 K/1 yr	180	C/D
Vent-Axia	ACP100	125	67	NA	NA	3 yrs	120	C/D
<b>IN-LINE FANS FOR SINGLE OR MULTI-ROOM EXHAUST (HVI RATED &gt; 200 CFM)</b>								
American Aldes	A-6	262	4.5	87	√	80 K/2 yrs	130	C/D
Fan Tech	FR150	250	NA	90	√	80 K/2 yrs	120	C/D
NuTone	QT300	300	4.5	275*	√	life	220	G
Panasonic	FV-35VQ	350	3.0	117	√	30 K/1 yr	250	C/D
Vent-Axia	ACP150	250	NA	100	NA	3 yrs	120	C/D

\* indicates Green Seal estimate.

**Volume** HVI rated fan capacity volume in cubic feet per minute at 0.1 water gauge (WG) static pressure (air flow is also measured at 0 and 0.25 WG — capacity is reduced at higher static pressure). HVI certification indicates that the product has been tested by an independent laboratory according to HVI requirements and met HVI certification guidelines. HVI (Home Ventilation Institute) is an independent industry organization (708/394-0150).

**Noise** Rated product noise in sone. One sone is approximately equal to the sound of a refrigerator in a quiet room. HVI also handles testing and certification of home ventilation products.

**Power** Fan motor power consumption in watts, as reported by the manufacturer. “\*” indicates estimated power consumption based on reported motor amperage ( $W = V \times A$ ). Choose products that provide the CFM needed at the lowest rated power. It is possible to compare fans by looking at their respective cfm/watt ratios, however this is not a common measure of efficiency.

**Bearings** A check mark (“✓”) indicates that the fan has sealed motor bearings. Sealed motor bearings generally require no lubrication and tend to last much longer (“NA” indicates information not available from the manufacturer).

**Hrs or Warranty** Rated motor life in thousand hours (where available) and/or manufacturer’s warranty on the product. Some distributors and catalog sales outlet, such as Tamarack Technologies offer a 5 year warranty on the products and parts, regardless of manufacturer warranties. “Life” indicates that the product is warranted for the life of the house (or as long as the original owner). 30,000 hours is approximately 3.5 years, 80,000 hours is approximately 9 years.

**Price** Estimated product price. Pricing is dependent on volume/order.

**Avail.** Product availability. “C” indicates that the product is available through catalog sales; “D” indicates that the product is available through distributors; “G” indicates that the product is available through regular retail channels. Distributors/manufacturer contacts: American Aldes (800)-255-7749; NuTone (800) 543-8687; Panasonic (201) 348-7231; Tamarack Technologies (800) 222-5932 — distributors of Vent Axia and Fan Tech.

## What is an active ventilation system? Continued from page 4

■ a timer or other control mechanism to control the system cycle.

Recommended air changes can be achieved in a stand-alone system by using a single long-life fan to extract air from several rooms in the house (flexible ducting is run to the central fan from multiple exhaust points such as baths, laundry room and kitchen.) The system can be designed for either intermittent or continuous operation. Fresh air is introduced through makeup air inlets to replace the air being exhausted.

In an integrated system, the HVAC circulating blower provides the power to pull in fresh air from the outside. Because a forced-air system can draw in much more outside air than needed, this type of system depends on a balancing damper to control the volume of fresh air that enters the house. The damper settings are based on the calculated volume of fresh air flow needed and set using an accurate air flow measuring instrument.

Integrated systems are the most complex to install and calibrate. Stand-alone systems can be lower in cost and can be installed in older houses that have been retrofitted for energy efficiency. With stand-alone and integrated systems, care must be taken with the fresh air source to avoid the reintroduction of inside air or appliances’ combustion exhaust.

## Heat and Energy Recovery Ventilators

As their name implies, heat recovery ventilators can recover a significant portion of winter heat that would otherwise be lost in the exhaust air from an active ventilation system. Their counterparts, known as energy recovery ventilators, are designed specifically for summer use and can cool and dehumidify incoming air using the exhaust air stream. These specialized devices reduce cooling and heating energy consumption while providing a home with a steady flow of fresh air.

These devices make economic sense in areas where a long heating or cooling season makes active ventilation a significant source of heating or cooling loss. The added cost for these devices is best justified in extreme climates, where there are large indoor/outdoor temperature differences for long periods of time.



## Available Ventilation Products

We rated the fans associated with a number of manufacturers’ active ventilation systems. The fans selected are appropriately sized for whole house ventilation, generally under 200 CFM. We included some units above that capacity for commercial installation.

Active ventilation is a relatively new concept that is applicable to retrofitted and newer, energy-efficient houses, especially Energy Star Homes and those meeting the Model Energy Code (MEC), quality-built houses that exceed energy codes and are designed from the outset to provide their owners with lower energy bills. Active ventilation products and systems are

*continued on page 8*



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### *Available Ventilation Products Continued from page 7*

developing, as are guidelines for selection. Often, builders may have to assemble a system on their own, using parts from various suppliers. We used the selection criteria listed below to identify a number of fans, stand-alone and integrated products. Air duct products and duct sealing in general will be covered in a separate report.

■ **HVI rating.** We looked for fans that carry the Home Ventilating Institute (HVI) ratings. HVI is a nonprofit organization that has developed rating procedures for home ventilation products. Products that carry the HVI certification have had their fan capacity and noise levels claims verified.

■ **Energy efficiency.** We looked for fans with energy consumption levels of 60 watts or below.

■ **Noise.** We looked for fans with low noise ratings, HVI rated at 1.5 sones or less at 120 CFM. Quieter systems can help owners more readily accept these systems. (One sone is equivalent to the sound of a quiet refrigerator in a quiet kitchen.)

■ **Motor life.** We looked for long lasting products. Fan motors should be rated for a minimum of 10,000 hours, or be warrantied for at least 3 years.

### **RESOURCES**

The EPA Energy Star Homes program toll free number is 888-STAR-YES (888-782-7937) or ([www.epa.gov/docs/GCDOAR/homes.html](http://www.epa.gov/docs/GCDOAR/homes.html))

The Indoor Air Quality Information Clearinghouse (IAQ INFO) is an easily accessible, central source of information on IAQ issues. (800-438-4318)

## **OTHER GREEN SEAL PUBLICATIONS**

*Green Seal has published a number of **Choose Green Reports** that provide detailed guidance in purchasing products with less impact on the environment. Topics include Interior Latex Paints, Carpet, Building Materials, and Occupancy Sensors. Please contact us for information on obtaining these reports.*

